Field Performance of a Deployed IR Perimeter / Border Surveillance System

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1. Introduction

This paper discusses the performance, deployment issues, and lessons learned associated with fielding the Argus Falcon Thermal Imaging System. Various deployments are discussed, as their fielding offers insight into positive and negative aspects for consideration in future similar system deployments.

This paper is broken into five sections.

Section 1 very briefly introduces the product being discussed.
Section 2 discusses the performance of the product in various deployments.
Section 3 summarizes lessons learned from various deployments.
Section 4 describes, for reference, the product and background.
Section 5 summarizes the covered topics.

Raytheon Amber supplies Infrared cameras and components to commercial and military markets. One of the applications has matured into a deployable sensor system. These Argus Falcon systems have been deployed to a number of locations, involving a wide variety of environmental conditions, and a variety of threat scenarios.

Environment	Location	Targets	User
Hot, Very Humid	Southeast Asia	Seaborne (sampans)	Asian Government
Very Hot, Dry, Dusty	Saudi Arabia	Landbased (people, vehicles)	U.S. Air Force
Hot, Dry	Mojave	Airborne, Landbased (helicopters, vehicles)	U.S. Army
Cold	Taejon, Korea	Landbased (people, vehicles)	Korean Evaluation
Paradise	Santa Barbara	Seaborne (swimmers, rafts)	Korean Evaluation
Very Cold	Colorado	Landbased (people)	U.S.A.F. Evaluation

Figure 1. Sample of Argus Falcon Deployments

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14. ABSTRACT
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The Argus Falcon system is comprised of 2 major assemblies, the sensor and the controller, with component key features as summarized in the table below. For more information, refer to section 4.

Level	Component	Description
System	Argus Falcon Thermal Imager	Tactically deployable turn key long range day/night surveillance system
Subsystem	Argus Remote Sensor	Modular daylight and IR cameras mounted on a fast, accurate positioner
Line Replaceable Unit	IR Tube	Sealed housing incorporating IR camera, lense, and temperature control
Shop Replaceable Unit	Aurora	Remote controlled InSb 256 x 256, 38 um pitch, rolling integration ruggedized camera
Shop Replaceable Unit	Lense	Remote controlled switchable 25 mm, 100 mm, and 500 mm focal length refractive lense
Line Replaceable Unit	Daylight Tube	Sealed housing incorporating remote controlled CCD camera and 25 to 350 mm zoom lense
Line Replaceable Unit	Pan / Tilt	Remote controlled positioner allowing 20 °/sec, 360° azimuth, ±60° elevation camera pointing
Subsystem	Controller	Deployable case configuring joystick and pushbutton control of sensors and motion

Figure 2. Argus System Configured into Separable Components

2. System Performance

The Argus Falcon system is principally intended for use as a surveillance system, with the objective of target detection and threat classification at long range. There are many environmental and target specific factors which make definitive range performance specifications difficult to establish and verify. Nonetheless, users are typically not concerned with considerations such as relative humidity, target emissivity, integration times, offset gains, or minimum resolvable delta temperatures. The users of this type of system are typically civil or government law enforcement users wanting relatively straightforward setup and operation.

They are likewise concerned with their issues of how far they can detect and identify a target and how well they can track it. They, therefore, look for simple verification methods such as putting an often ill-characterized threat at range and then trying to find it. Identification of the target adds a whole new layer of opinion variation between evaluators and discussion of definitions. The system’s resolution combined with the sensitivity, and the long lense (allowed to be practically sized given the FPA sensitivity) lead to extremely good long range imagery compared to most deployed technology.

Nonetheless, if it can’t see the threat, the users lose interest fast. Quite innocently, inquiries of ability to see through buildings and into deep water routinely come up. One customer complained that their country allowed no place to adequately demonstrate the maximum range.

All of that said, the issue comes to specifying performance, and field verifications of the performance. After discussion with multiple customers about their threats, a set of testable specifications have been established. While some may be vastly exceeded, the same specifications, under different conditions, may be quite challenging. The following are example "real world" specifications for the Argus Falcon systems. These were for a particularly humid environment and performance far exceeding these specifications have been recorded.

Parameter	Medium Target	Small Target
IR Detection Range:	7.8 km	4.4 km
Visible Detection Range:	12.8 km	7.8 km
Tracking Speed:	20 degrees / second	
Sun Saturation:	Recovery within one second	
Warm Up Time:	Less than 15 minutes at +60°C	
Length	20 m	4 m
Width	6 m	1.5 m
Height	6 m	0.5 m

Figure 3. Typical Performance Specifications

Other specifications of interest, but not practically verified in the field are typically provided with analytical or lab measurement substantiation. An example is noise equivalent delta temperature specification of 0.025 °C (at 27 °C) and the MRDT performance as shown below.

Target Number	k cycles/mr	k/kN	Tbar-Tback (degC) hot bar A	cold bar B	dt (corrected) (A-B)/2	MRTD dT x t collim	TS error (for ref) (A+B)/2
3	0.10	0.015					
4	0.20	0.030					
5	0.50	0.076	**0.032**	**0.020**	**0.0060**	**0.0055**	**0.026**
6	0.75	0.114					
7	1.00	0.152	**0.042**	**0.025**	**0.0085**	**0.0078**	**0.0335**
8	1.33	0.202					
9	2.00	0.304	**0.056**	**0.023**	**0.0165**	**0.0152**	**0.0395**
10	2.67	0.406					
11	3.33	0.506	**0.058**	**0.020**	**0.0190**	**0.0175**	**0.039**

Lens Focal Length:	500mm	Collimater focal length:	40 inch
FPA Pitch:	38 microns	Collimator transmit:	0.92
IFOV:	0.076 mrad	Bars:	Horizontal
k Nyquist:	6.579 cycles/mrad	Background Temp:	22 deg C

Figure 4. Minimum Resolvable Delta Temperature Performance

Environmental performance has played a crucial role in the survivability and reliability in various weather extremes. The following specified conditions have been verified through qualification testing though real world deployments occasionally offer additional performance challenges.

Parameter	Specification
Temperature:	-32° to +65°C
Vibration:	HMMWV Hard Mount (~Comp Wheeled Vehicle)
Blowing Rain:	102mm / hr @ 64 knots
Sand & Dust:	MIL-STD-810E Method 510.3
Salt Fog:	MIL-STD-810E Method 509.3
Humidity:	MIL-STD-810E Method 507.3
Solar:	MIL-STD-810E Method 505.3

Figure 5. Argus IR Tube Environmental Specifications

The typical surveillance threat is covert intrusion of people and small vehicles. This applies to both land and sea incursions. The small targets in warm seas have proved especially difficult, apparently given the high reflectivity and irregularity of the water. High humidity makes the challenge even greater due to the atmospherics involved. Low, slow flyers involve some ground clutter but tend to be fairly amenable to detection and even tracking. Landbased targets have tended to be the most straightforward to acquire and maintain, though tracking in a high clutter background (a person among others, a vehicle through a busy intersection), present difficulty.

Figure 6. Various Test Targets (Small, Medium, and Escort) in Asia

2.1 Range - Small Sized Seaborne Target

In field tests in an southeast Asian country, in summer of 1997, these performance specifications were verified. Specifically, detection of a sampan at 4.5 km was accomplished. One of the difficulties of the verifications was that they were in very humid conditions (impending rain) over seawater with a low target and the sensor not significantly elevated. With small targets in the marine layer at long grazing angle range, the conditions are quite challenging. The users were not sympathetic to the physical obstruction of the target by the wave heights, much less atmospheric impacts. As it turned out, due to the low height of the target, the system was actually keying off of the boat driver sitting in the vessel. At long ranges, the flat wooden boat was indistinguishable from the waves. Nonetheless, the small target was actually tracked at the maximum specified range.

2.2 Range - Medium Sized Seaborne Target

The medium target test, also in southeast Asia, was similarly successful, though with some attendant practical difficulties. There was no “medium” sized target available so a smaller one was used. Rather than argue the interpolation test range, the slightly smaller target, a PT boat, was sent to the maximum range and was detected quite well at over 8 kilometers (4.5 nautical miles). The height (approximately 3m) certainly contributed to the easier time with this target.

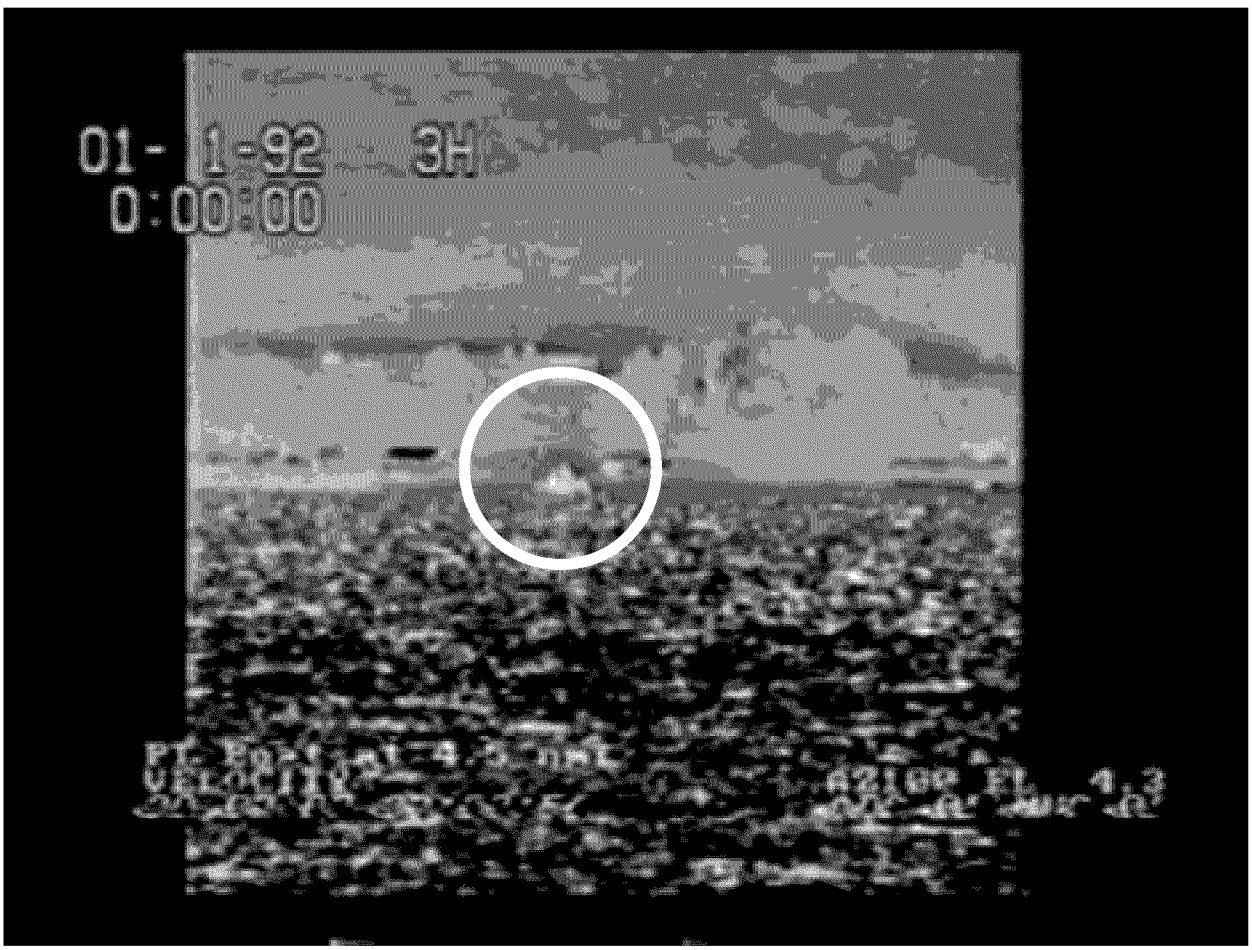

Figure 7. “PT Boat” at 4.5 Nautical Miles (8.3 km) in Asia

2.3 Tracking

Tracking performance, also in southeast Asia, was declared successful, though the test conditions were difficult. A number of factors, all real world issues, played into this difficulty. The sea state was such that the vessels were hard pressed to establish a high angular rate (at any real threat range, 20 degrees per second is an extremely fast rate). Given basic geometry, as the test target moved away, the relative angular rate decreased, and yet some amount of time was required to establish the track parametrics. Additionally, there were a number of other vessels which, typically thought of as targets of opportunity, in this case obscured the test target. Also contributing to the difficulties were that there was considerable glint off of the wavetops; this caused clutter that was not easily filtered out. The water was very warm and, in addition to reflecting the target image signature, the waves and wake registered significant response of their own. Lab demonstrations of very close in, very high rate targets illustrated the ability of the tracker to perform and, when used against targets of opportunity (as opposed to contrived specification targets), the tracker function performed adequately.

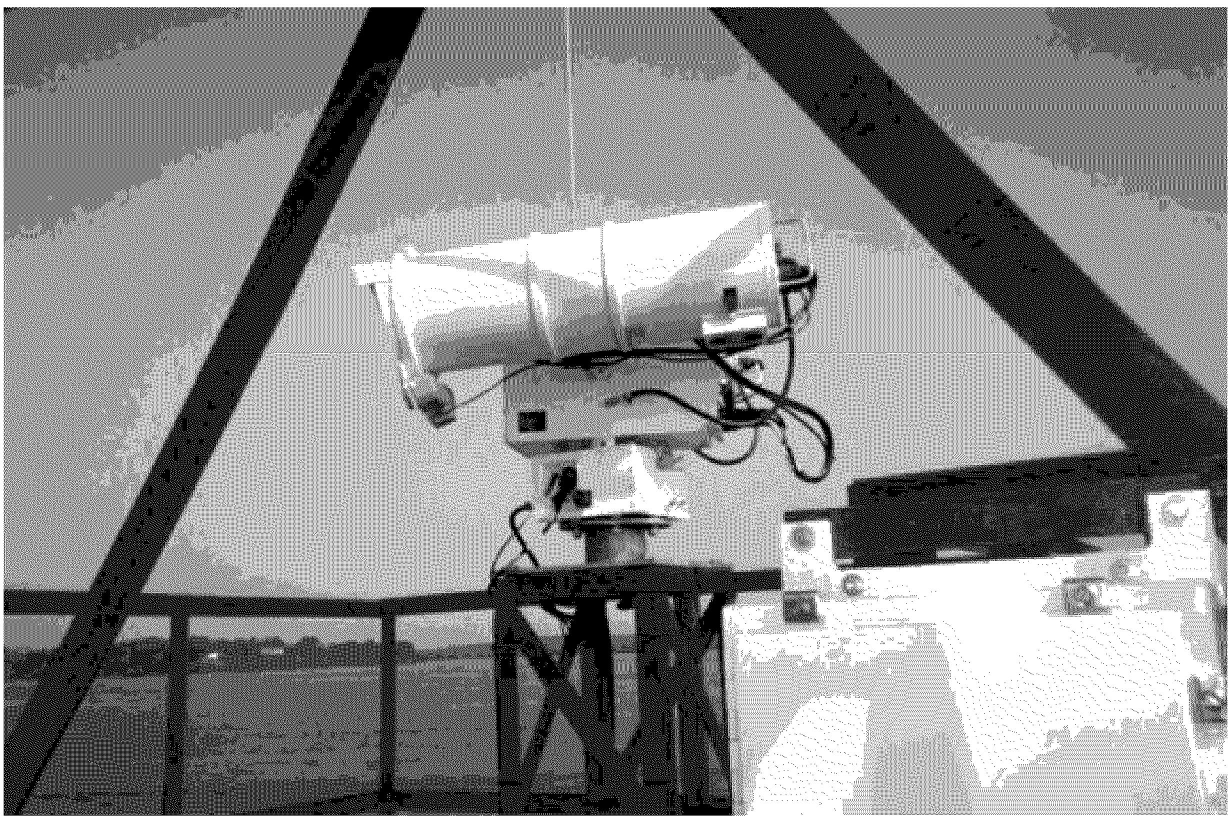

Figure 8. Argus Falcon Tracks Small Seagoing Vessels

2.4 Range - Very Small Sized Seaborne Target

On subsequent test trials, again in a sea environment, this time off the coast of Santa Barbara California in October 1997, detection of a swimmer was desired. The requested range was 3 km for a “covert” swimmer (wearing a wetsuit and not wildly splashing about). The threat scenario was a small inflatable boat launched insertion of swimmers onto a remote beach at night. This demonstration occurred on a relatively calm, cool, sea with a fairly clear sky. The sensor was approximately 30 meters in elevation. The reflection of the cold sky can be clearly

seen in the videos. The favorable conditions, and the inherent performance of the system, led to detection of the 3 meter avon, it's driver, and the swimmer at 6 kilometers. The wetsuit clad swimmer could be observed getting out of the raft, into the water, and his bobbing head monitored as he moved from the raft. The effect of submersion and reappearance could be seen as the water ran off his head. At the 3 km specified range, the swimmer was very successfully monitored from the ingress of the raft, through swimming to shore, on shore, returning to the raft, and egress from the area. In the very dark environment, the raft pilot required that directions to the returning swimmer be radioed from the camera operator!

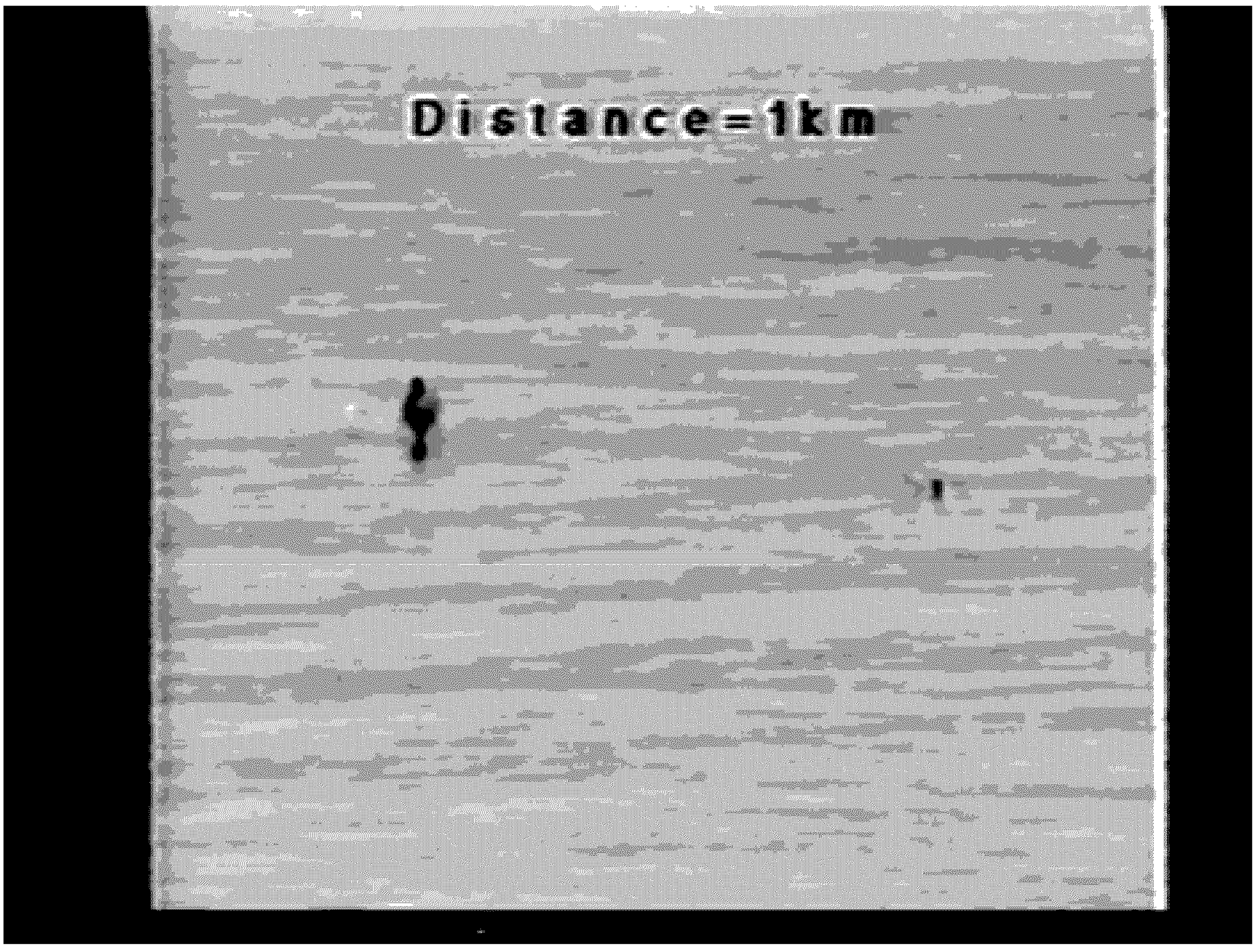

Figure 9. Swimmer and 3m Zodiac Are Easily Observed in Pacific (Black Hot)

2.5 Cold Climate Deployments

The Argus Falcon was setup for a field exercise in Taejon Korea in November 1997. The temperature at night was in the mid to high 20s (F). The scenes ranged from forests (nearly ambient temperatures) to the city (warm targets). There has been much discussion of IR performance at cold climates. The suggestion that midwave system performance may be inadequate at cold, due to insufficient flux density, bears little impact to lab testing done (to -25 F) and the real world performance of the system (to mid 20s F) in Taejon.

A somewhat more mundane lesson, learned in another cold climate (Buffalo NY), despite fine image performance, was that, at very cold temperatures, the small motors used to drive the optics in lenses are subject to slowing down. This appears to be caused by a combination of effects including reduced drive current, and increased lubricant viscosity. The systems now enjoy "oversized" the motors and drive circuits. A side benefit is that, at normal temperatures, the switch time is much faster. This is a difficult lesson to learn in a temperature chamber, or in the confines of the relatively featureless environment of Santa Barbara, but comes to bear quickly in field operation.

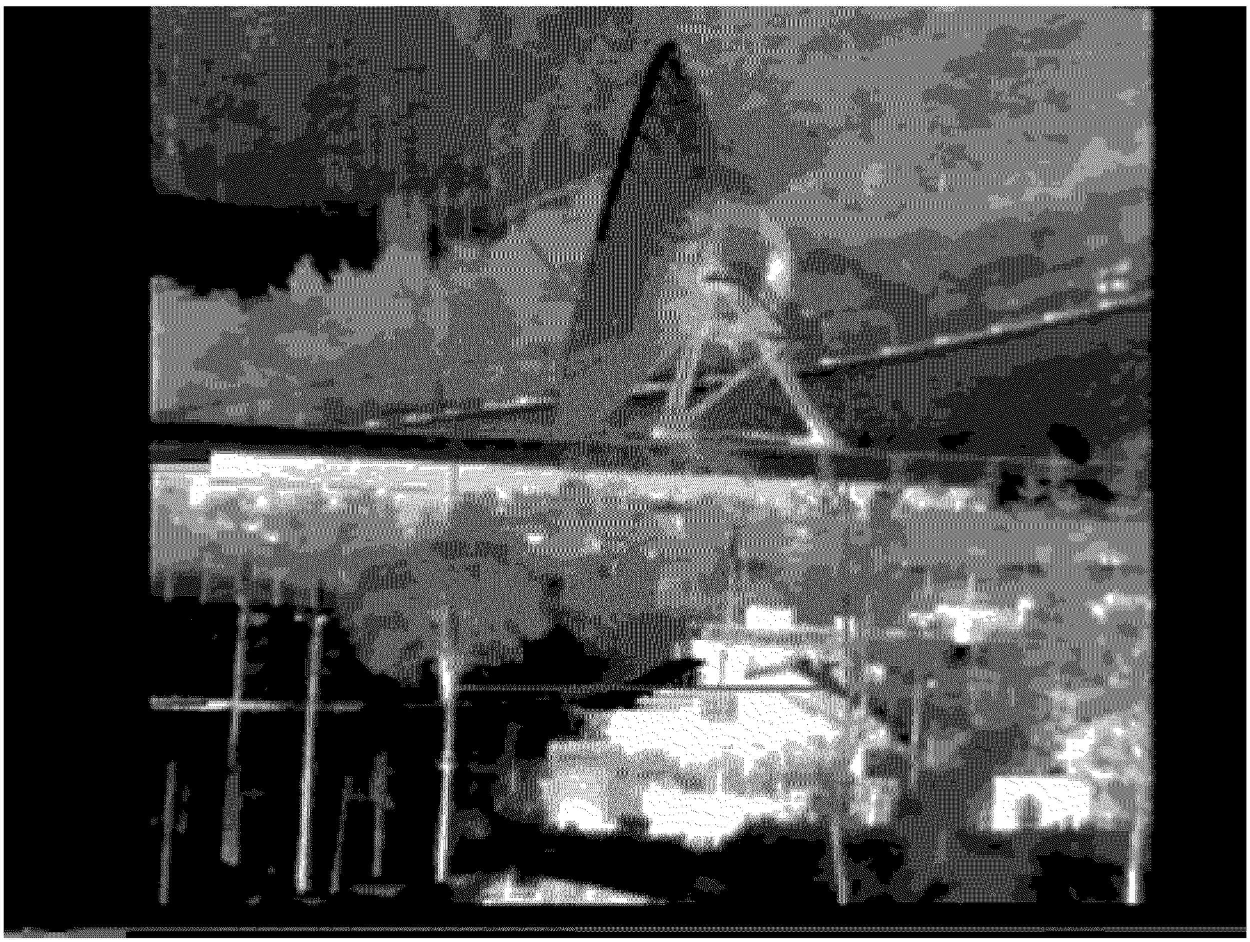

Figure 10. Scene Clearly Distinguished in Cold Korean Environment

2.6 Changing Environments

The ability of the system to function at low temperatures and also at high temperatures should not imply that there are not corrections required. This were learned in a demonstration deployment in December 1997 to Colorado Springs, for the U.S. Air Force. The deployment had temperatures down to 17F. While this alone should have been fine, the system in use had recently come from an Asian setup with hot humid camera optimization. This, combined with poor operator training, and having allowed no dry run time between the Asian setup and the Colorado demonstration, led to a display of an image far below optimal quality.

The obvious need is having a range of integration times and gains available to chose from to suit the scene temperatures. In addition, there need be either a widely variable calibration

mechanism, or the ability to calibrate to an external source; this ability need necessarily exist at the field user level to allow adaptation to different scenes. This was the undoing of the Colorado exercise; the participants were not versed on the required scene based recalibration.

2.7 Vehicle Mounted Deployments

There are currently two deployed versions of vehicle mounted Argus Falcon systems. One system has the entire Argus sensor mounted to an pneumatic mast on a mobile shelter; the rack mounted control electronics are installed inside the shelter. The other version has the Argus IR Tube mounted on a pedestal on an Army HMMWV. Both systems have brought to light different aspects of operation which may not typically be associated with surveillance systems.

The primary, though obvious, issue has been vibration. The sensor was first qualified, for the mobile shelter, to the equivalent of Mil-Std-810D basic transportation levels. The control rack was built on isolators but not tested. Given that much of the system relies on commercially available technology, there is little inherent ruggedization. There are computer chassis' in both the sensor, and the control rack. All of them have suffered, at one time or another, card seating problems. This, despite the prescreening and qualification testing that took place. The obvious response is that the real environment is not reflected by the specified levels, though this does little to assuage the user's frustration at intermittent operation. The recovery actions were fairly straightforward, including foam and strap retainers, and removable adhesive for the cards.

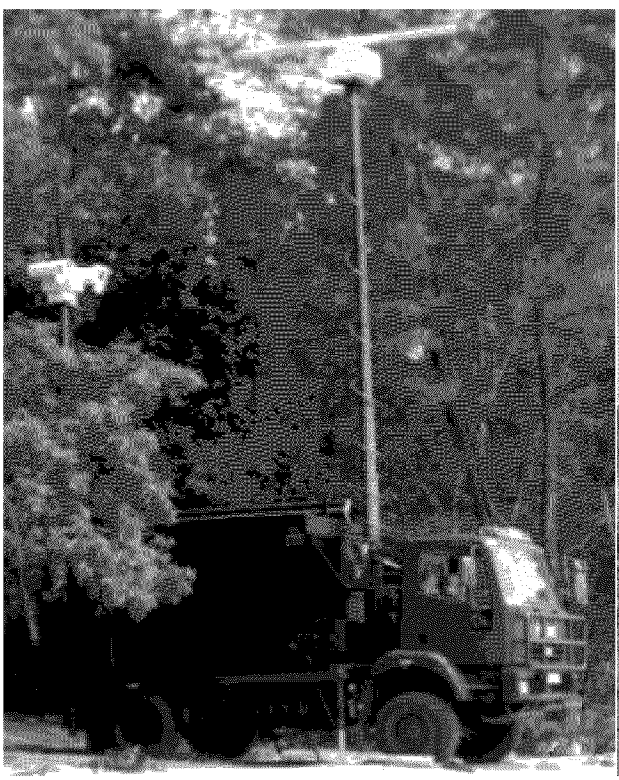

Figure 11. Argus Falcon in S.E. Asia

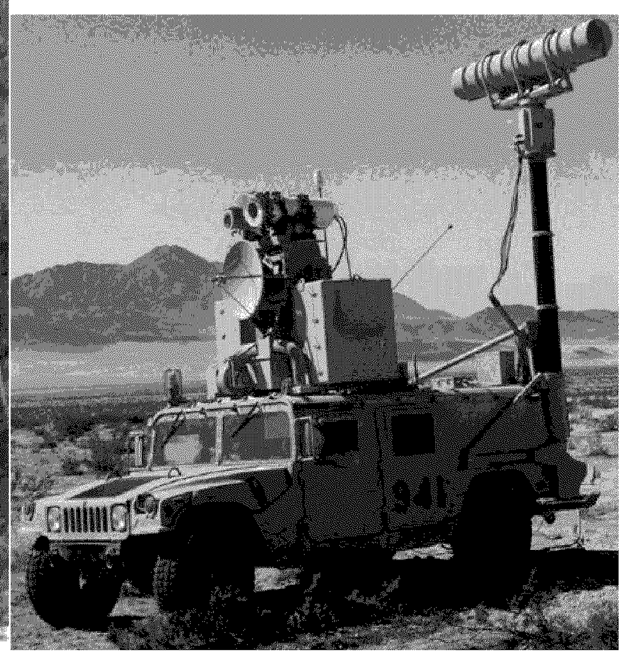

Figure 12. Argus IR Tube in Mojave

The IR Tube has subsequently been qualified to the equivalent of composite wheeled vehicle levels. Again, though there was significant prior screening, design modifications were required to accommodate the loads. In this case the deficiencies became apparent in formal qualification (the qualification dry run, as tends to happen, went smoothly). Corrective actions included redressing soldered flying leads, and prodigious use of locking compounds.

2.8 Middle East Desert Deployments

The Argus Falcon is currently deployed to the south of Riyadh, Kingdom of Saudi Arabia, at Prince Sultan Airbase (PSAB), serving as the “Eyes of God” in protection of the coalition air base. The conditions there are less than luxurious in terms of the ability to operate and maintain equipment. The location is considered a remote tour and most personnel transfer in and out every 4 months. While the Argus Falcon is well suited for this environment given the simple operator interface and low required maintenance, the remote location, general disposition, and tight restrictions make it challenging to support.

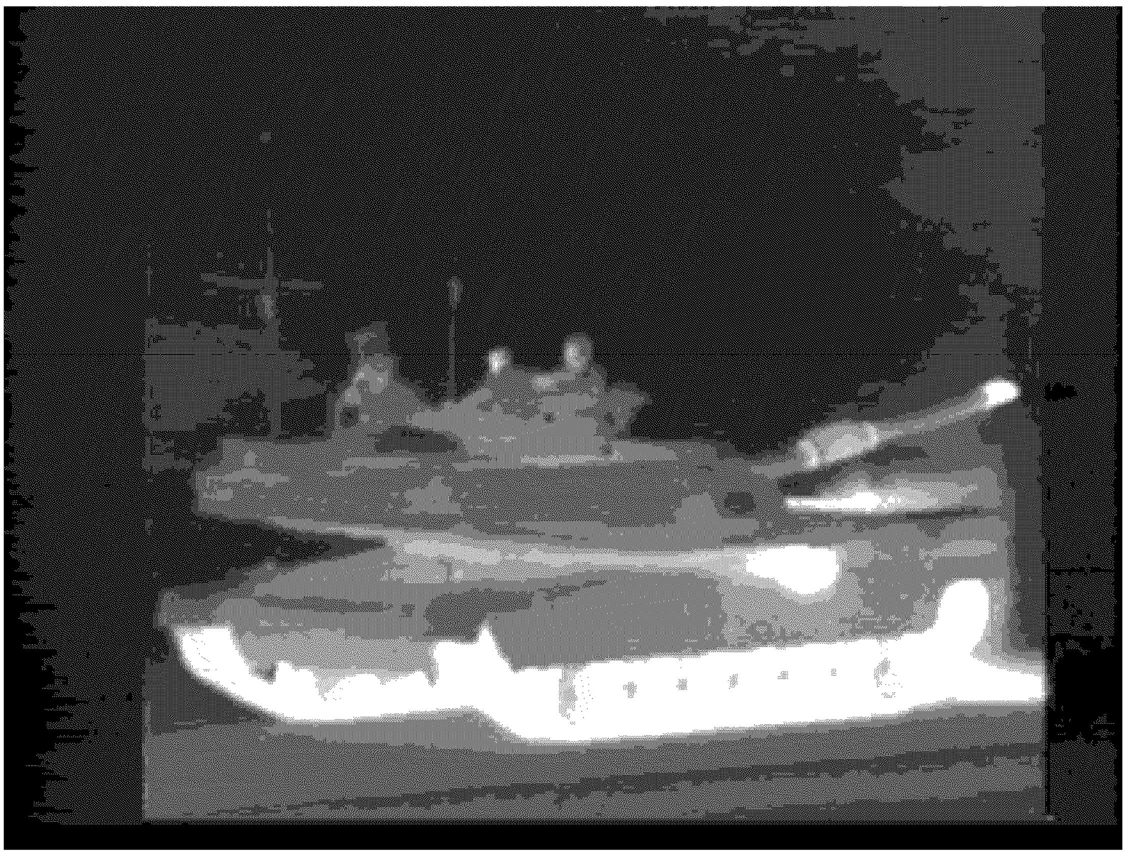

Figure 13. Saudi M1 Abrahms in Tabuk, KSA

One of the Middle East difficulties was the less than optimal transportation conditions. On one occasion the equipment was commercially contracted for delivery to a remote field site. It rode loose in a stakebed pickup truck, for an hour over open desert. The equipment arrived with every card loose, fasteners broken and cables intermittent. The availability of test equipment and tools was nonexistent and the difficulty in traveling through the airports with tools (Swiss army knives were prohibited) only exacerbates the problems (though many screws can be worked with 5 pence notes). On another occasion, a military shipment of a spare IR Tube arrived with the camera literally loose inside. The camera lost it’s heat sink and failed.

Figure 14. The Argus Falcon DCU at Coalition Forces Air Base

The system performance, once established as operational after the journey there, is outstanding. Though there is much consternation about the heat and the pervasive dust, both are expected and have apparently been addressable using up front design practices. An interesting effect was that the temperature about 30 feet above the ground was reportedly higher than that at ground level (the prevailing theory being that there is a reflection set up).

Figure 15. Tent City at Prince Sultan Airbase, KSA

Another note about the Middle East deployment, is that, given the remoteness and attendant difficulties with supporting the sites, coupled with the very obvious concern of constant coverage, there should be spares set up on site. The sensor, as the industry is aware but the consumers find difficult to accommodate, will necessarily have a cooler failure at some point. When this happens there will be a downtime associated with the rework. Though spares are not negligible cost, the forecast system outage could be avoided.

3. Lessons Learned

The system has been deployed, thus far, to widely varying environments. These deployments have faced targets on land, in the air, and at sea. Some of these conditions are reflected in the table below. Through the course of these activities, positive attributes have been highlighted (the good), some negative experiences have led to lessons to avoid in the future (the bad), and some difficult aspects have been acknowledged as hard to avoid but nonetheless worth trying to make the best of (the ugly).

3.1 The Good

Good engineering and thorough planning has lead to some successes. These have lead to the systems being deployed, praised by the users, and recognized by other inquiring users. The basic camera capability, instilling high performance sensors in a turn key package, and the overall system philosophy of making it simple to use have been positive overriding attributes.

3.1.1 InSb is the FPA of choice

The selection of InSb as the foundation for the system has proven to be wholly rewarding. The midwave system has been extremely effective in hot humid environments, especially when compared to uncooled, or longwave systems. Additionally, the same system performs very well in cold climates (allowing that the user's can adjust the necessary parameters for the wide scene variation), and of course, the performance is outstanding in clear dry atmospheres.

3.1.2 Camera Performance Adjustability

Despite the propensity to design to one particular specification, putting the camera performance parameters in as operator variables allow the product to be used widely, without costly rework actions. The provisioning for easy manipulation of key performance variables, such as integration times, gain, and calibration temperatures has been essential in the success of this camera performance over the wide range of environments.

3.1.3 Simple User Interfaces

Putting the controls in a straightforward user interface has been extremely valuable in putting the system to use in the hands of real operators. It is, sadly, not uncommon that the users have very little opportunity for advance training, and even when they do, they often transfer out so fast there is little motivation to master a complicated system. Though the more sophisticated users want access to all of the variables, the typical user of this surveillance system just wants it to work simply and reliably.

This system allows a tiered control, where all essential functions, and most used "once-in-a-while" functions are at a single button push; the more in depth controls, calibrations, or performance optimizations are available through a computer interface. The line is difficult to draw but very important. Adjustments to that line, such as putting an external calibration function at easy user access, come out of these real world deployments.

3.1.4 Environmental Seals

Though deployments have only been accomplished over the last year, the apparent success of the environmental seals is encouraging. The upside is that the units are fitted with inspectable desiccator cartridges which give the viewer insight into the condition of the internals. The downside is that this presumes someone will inspect them. One system has come up with a corrosion related failure, with completely pink desiccators. A lesson here is that the maintenance seals (the desiccator cartridge and the purge valves) should be glypt marked to indicate positive closure.

3.1.5 Sunshield

The system incorporates sunshields for both cameras. This not only reduces glare but also, combined with the basic tube structure, seems to keep the feared bird roost problem at bay.

3.2 The Bad

Some experiences can be learned from. These were typically not pleasant at the time but, in the cases below, have led to systems improvement which facilitate downstream deployments. The reader is encouraged to avoid these pitfalls to the extent possible.

3.2.1 Too Much Mass

The desire to pack as much functionality into a system as possible has led to building some very heavy items for deployment. While it may generally be perceived that heavy connotes ruggedness and reliability, the mobilization of overly heavy systems has proved very difficult. This lesson came from hauling an 800 pound rack of equipment up marble stairs in the outback of northern Saudi Arabia. The upside is that the systems have since been broken into separate deployable cases which are simply wired together on site.

3.2.2 Rack Density

Another related lesson is that, even for modular racks, stuffing the racks such that the equipment is not serviceable is a problem. The problem may not be sufficiently appreciated in the lab but, once in the field, inattentiveness to rack layout can cause significant frustration.

3.2.3 Practice in the Known Environment

This could also be known as “Trained Operators Should Operate” or even as simply as “Try It First”. The lesson came from not being able to simply recalibrate a system to the appropriate environment (going from equatorial hot humidity to Colorado cold). Depending on perspective the lesson is either build better controls, or come better versed, or allow time to practice. All three are probably valuable lessons.

3.2.4 Commercial Card Cages

One of the most frustrating and yet correctable field failures has come of using commercial card cages. The military has occasioned to taking desktop PCs to the field because they are used to them, and they generally work. The contractors have followed (or led) suit by building commercial products into deployable systems. While this practice successfully minimizes custom design costs and schedules, it should not be taken without thought. The commercial card cages have edge connectors which may become unreliable, operating systems which are held by batteries that are unreliable and / or not replaceable, and card retention methods that suit a desktop environment. All card cages going into the field should have the cards positively engaged, retained, and tested.

3.2.5 User Service

Allowing access to internal LRU components, at even the simplest level, can be problematic without adequate training and support. The tendency to allow field service, by deployed personnel, has led to further failures. A lesson learned by the “big” military has been to set up established, controlled, trained depots. With the increasing use of “commercially available” technology, there has been some tendency to relax these rules and work on things in the field. Though it is typically a balance of up-time, and effort level, hard discretion should be used when allowing field maintenance.

3.3 The Ugly

Some aspects of system deployment are difficult in any case. Preparation and patience are key. Awareness of the pitfalls is useful but may not allow avoidance.

3.3.1 Glint

The seaborne target clutter simply put, makes contrast based tracking difficult. The South China Sea offered difficulties with tracking of small vessels. The wavetops and wakes provided significant signatures, often competing with the target vessel.

3.3.2 Equipment Transportation

Some areas of the world simply do not well facilitate equipment transportation. Most notably was Saudi Arabia where even well packed equipment was handled mercilessly by commercial shippers. Parts of Asia were difficult also. It is suggested that deployment personnel (those that will be counted on to operate the equipment) personally transport the equipment. Unfortunately, this is often impractical. The only option is to try to invest in packing and shipping methods commensurate with cost of field failure.

3.3.3 Tools

Being in a forward deployed area without the ability to service equipment is foolhardy. Of course this includes equipment and trained personnel. This may seem to contradict having a capable rear depot but rather allows another level of flexibility. When called for, downtime for want of the right tools is frustrating for the operators, supervisors, and support personnel. Inclusion of an “emergency kit” or specification of required but not supplied tools is useful.

3.3.4 Spares

A related lesson, though maybe difficult to convey to users, is that having spares on hand greatly reduces the stress associated with inevitable down time. This is a simple concept but is often sacrificed for the bottom line. The result is inevitable system outage with difficult fallbacks.

3.3.5 Too Much Information

In an effort to draw the line between simple operation and available information and controls, some users report failures due to misunderstanding of the information made available. This may be a lesson learned to make all interfaces bulletproof or it may be a “take your medicine” character building exercise in that there is no pleasing everyone all of the time.

4. Background and System Description

Raytheon Amber, part of the newly created Raytheon Systems Company, operates in Santa Barbara California. The provides cooled and uncooled infrared imaging sensors to the worldwide commercial, industrial, and defense markets. The company has capabilities from making focal plane readouts to sensor engines to cameras to turn key surveillance systems. The result is a line of easy to use, high performance, commercially available imaging products.

The surveillance systems component of Raytheon Amber started as a method of providing the camera technology to users who were not inclined to perform system integration. The result is a product line that is being used as both turn key and integrated system components. Typical applications are border and coastal surveillance, and sensitive site protection. Other applications include observation, tracking, and targeting of airborne and other platforms.

4.1 Argus Falcon

The Argus Falcon system is a family of components which can be mixed, matched, and customized according to the user needs. The key component is the Aurora IR camera. This camera is integrated, as a shop replaceable unit (SRU), with a long field of view lense, into an EMI and environmentally sealed enclosure, resulting in a line replaceable unit (LRU), the IR Tube, which is the heart of the system. “Ancillary” equipment enabling the use of the IR Tube includes a high speed positioner, a daylight camera Tube, and various configurations of controllers. The sensor, constituted of the camera tubes and the positioner, has been through environmental qualifications including temperature, vibration, rain, and salt fog.

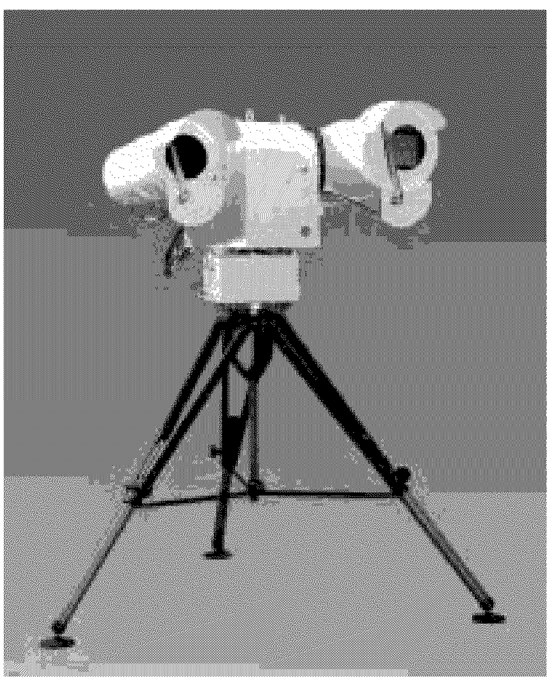

Figure 16. Argus Falcon Sensor

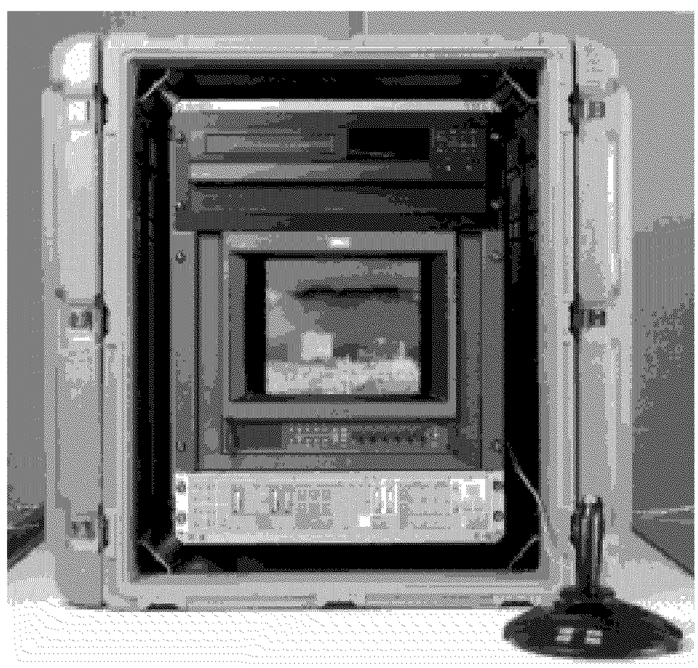

Figure 17. Tactical Display & Control Unit

4.2 Aurora Camera

The Aurora is one of Raytheon Amber’s production cameras. It is a repackaged derivative of the Radiance camera; the repackaging removes the user interface and ruggedizes the unit for

installation into Tubes. The camera is based on a cooled Indium Antimonide (InSb) focal plane with 256 x 256 pixels at a pitch of 38 microns. The electronics provide a rolling integration image processing with the typical variable region of interest manual or automatic gain control, integration time selections, black hot / white hot, and other standard camera functions. The camera also provides for on screen text annotation which becomes useful in the video taped surveillance applications.

4.3 Three Field of View Lense

The Aurora Camera is mated to a three field of view refractive lense incorporating 25 mm, 100 mm, and 500 mm focal lengths, proving fields of view of 22°, 5.6°, and 1.1° respectively. The positions are switched into place using a rotating carousel. Focus is remote controlled and the lense incorporates an automatic focus compensation for thermal effects.

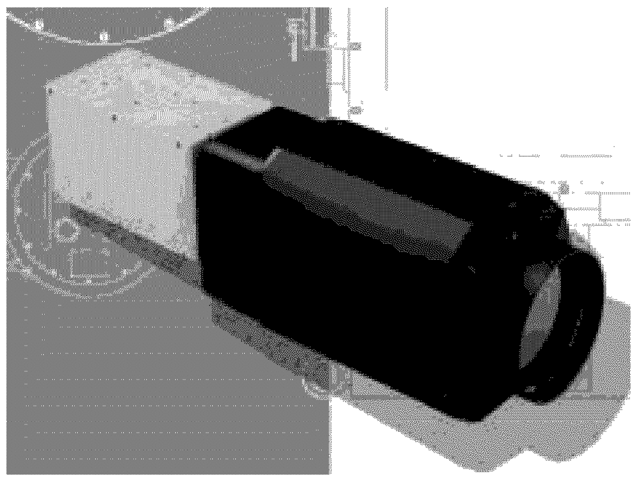

Figure 18. Lense Dominates IR Tube Components

4.4 IR Tube

The IR Tube is an aluminum cylinder containing the Aurora, the TFOV lense, and thermoelectric elements that alternately cool or heat the camera as a function of environment. The Tube is closed with end caps and sealed with closely spaced fasteners, conductive o-rings, and a chemically bonding sealant. This makes repair a bit more difficult but provides an effective environmental seal.

4.5 Positioner

The positioner uses stepper motors to drive kevlar belts allowing a continuous 360 degrees of azimuth rotation and +/-60 degrees of elevation. The slew speed is up to 60 degrees per second. The resolution and accuracy allow very fine positioning and long range repeatability. The unit incorporates on-board control computers and interfaces to the controller using a command / reply scheme over RS-422 . The communication with the controller is accomplished over a fiber optic link; video and communication pass over the link allowing hundreds of meters of separation with an easy to deploy means.

4.6 Controller

There are a wide variety of sensor controller configurations, as a function of user need. Some users have the ability to integrate the IR Tube or entire Sensor into their control scheme, others want a turn key operation. In an attempt to satisfy the turnkey users, and to provide a simple to

interface, easily demonstrable system, we have made a product of the tactical Display & Control Unit (DCU). This is a typically requested set of equipment packed in a Hardigg deployable 19” rack - case.

Sensor control is effected by a Raytheon Amber custom control panel. This panel allows a simple joystick interface to the sensor (controlling zoom, focus, pan, tilt, etceteras), and puts many of the system functions under single button pushes for the operator. The DCU also houses a monitor and VCR.

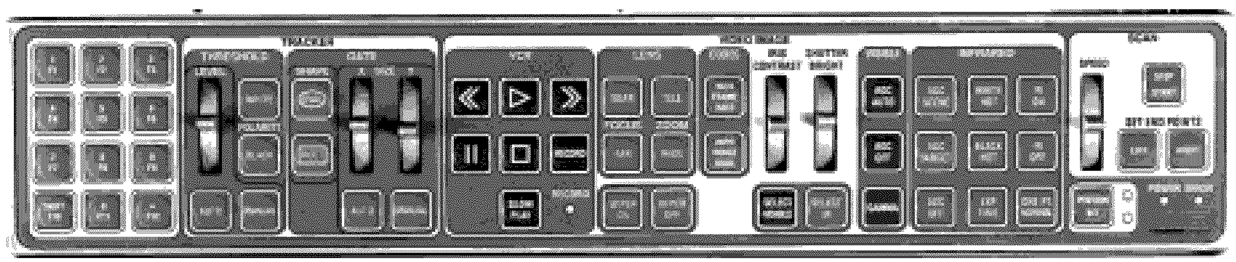

Figure 19. System Control Panel Contains All Essential Functions

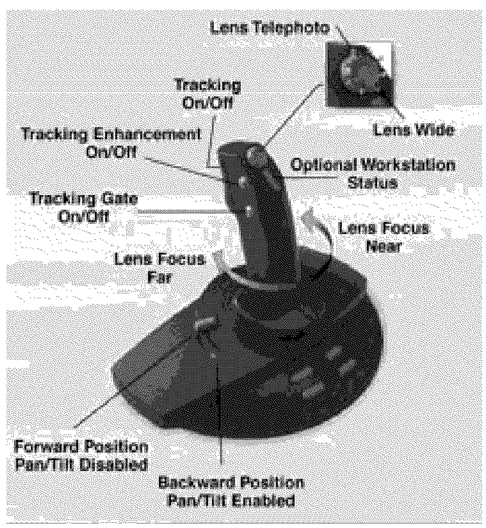

Figure 20. Joystick Control is User Friendly

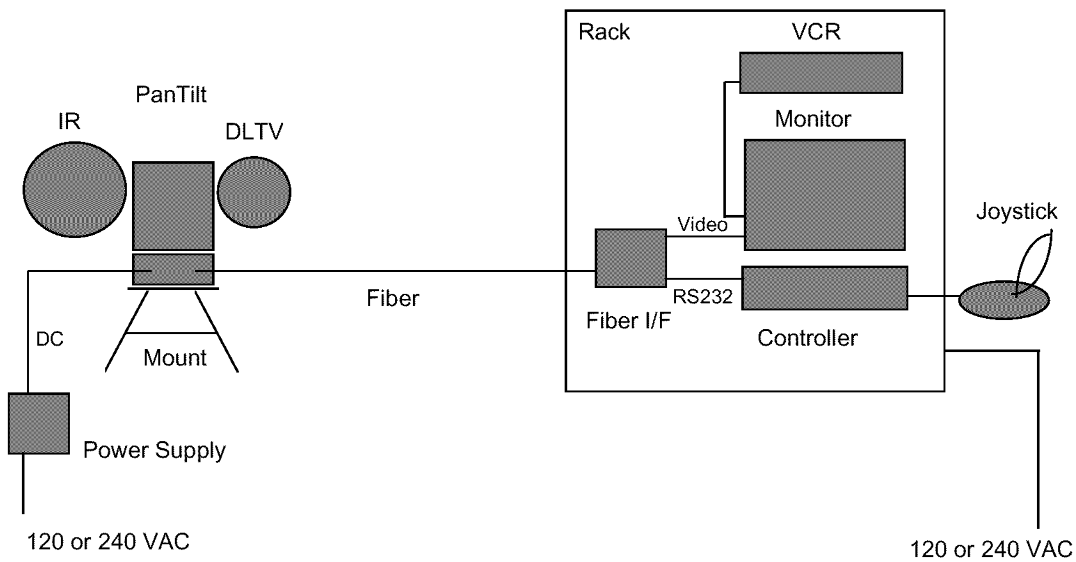

Figure 21. Basic Control System (Tactical DCU)

An even more minimalist control may be effected with a fiber transceiver and a laptop equipped with a video card. This is very useful for field integration and debugging. Additional features, such as tracking, multiple sensor muxing, video compression, and remote monitoring and control are added as a function of need. The most sophisticated deployed example of an Advanced Control System is deployed as an Asian border patrol system.

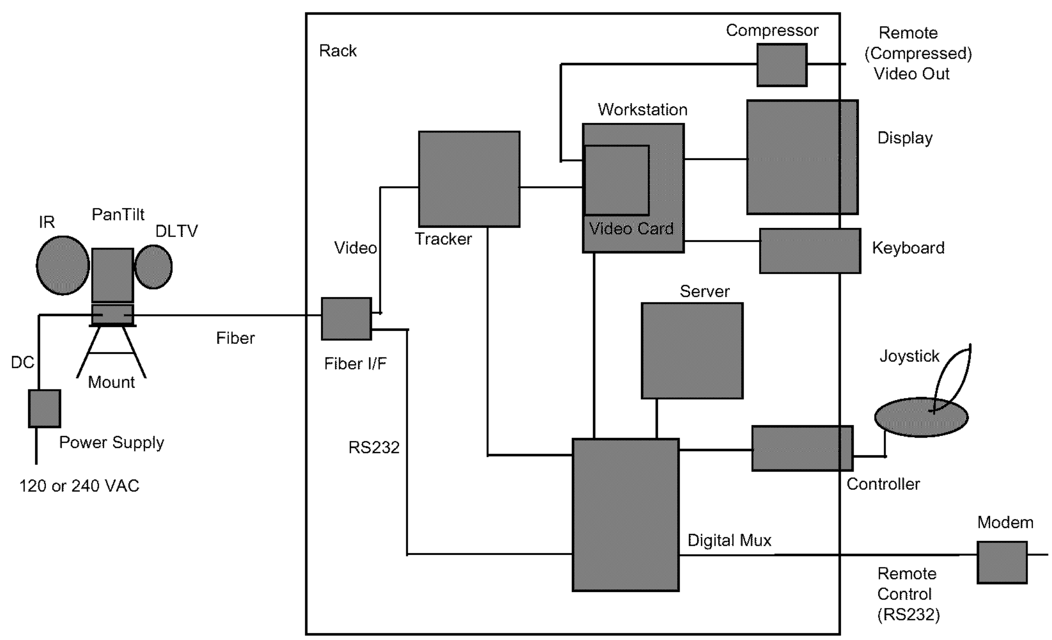

Figure 22. Advanced Control System

5. Summary

This paper has discussed various deployments of the Argus Falcon thermal imaging system. The system is a long range, environmentally rugged, deployable mid wave infrared surveillance system currently deployed in border monitoring, site protection, and targeting applications. Through the course of these deployments there have been lessons learned, of things that were good and of things that were in need of improvement. The system field performance, and these lessons, have been presented. It is the intent of this presentation that users and developers recognize various aspects of the IR surveillance system fieldings that, forewarned, they try to avoid problems.

These deployments have been made possible by the U.S. Army, U.S. Air Force, TRW, Sierra Research, and some Asian users. The users are typically military or civil police and have provided Raytheon Amber with opportunity to investigate system performance in real world settings. These personnel are typically the front line of defense to mal-intents. The conditions in the forward deployments are not to be envied and we appreciate the difficult role they perform. It is hoped that this paper helps in some way, now or later. Lastly, there are a number of Raytheon personnel without whom these systems would not have been built or deployed. They know who they are and share the intent that these systems be effective against the objectives.